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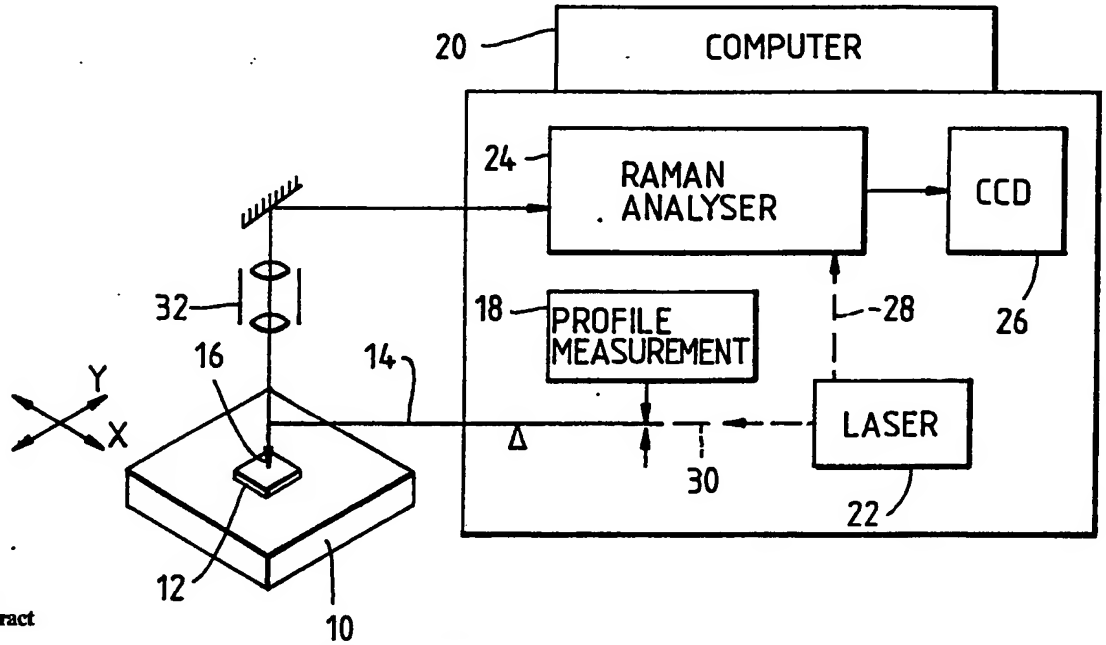

(57) Abstract

A profile measurement device (18) having a probe (16) scans the surface of a sample (12), acquiring topographical information which enables a computer (20) to build up a picture of the surface profile. A Raman spectrometer comprising a microscope bjective (32), Raman analyser (24) and a photodetector (26) in the form of a charge-coupled device provides spectrographic information such as the composition of or strain in the sample surface from place to place. This information is correlated in the computer (20) with the profile information, to build up a more comprehensive picture. The profile measurement may make use f a stylus which scans in contact with the surface of the sample (12), or it may make use of a scanning tip microscopy such as atomic force microscopy or scanning tunnelling microscopy. Optical determination of the surface profile is also described.

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SURFACE ANALYSIS APPARATUS

BACKGROUND OF THE INVENTION

This invention relates to apparatus and methods for analysing the surface of a sample.

One way of analysing a surface is to use spectroscopic techniques, such as spectroscopy using the Raman effect, for example as disclosed in our earlier International Patent Specification WO90/07108 (which is incorporated herein by reference). The Raman effect is a phenomenon in which a sample scatters incident light of a given frequency, into a frequency spectrum which has lines caused by interaction of the incident light with the molecules making up the sample. Different molecular species have different characteristic Raman spectra, and so the effect can be used to analyse the molecular species present. WO90/07108 described an apparatus which can be used either as a Raman microscope, or as a Raman microprobe. In a Raman microprobe, a spot on the surface of the sample is illuminated, and the Raman spectrum produced is analysed. In a Raman microscope, a two-dimensional image of an area of the surface of the sample is produced. This can, for example, be for a particular line in the Raman spectrum. This enables an image to be formed of the distribution of a particular molecular species over the illuminated area of the sample, by selecting a Raman line which is characteristic of that molecular species. Other spectroscopy techniques which can be used include fluorescence spectroscopy and infra-red spectroscopy.

As an entirely separate technique, it is also known to analyse the surface topography or surface profile of a sample. This is done, for example, to investigate the finish or roughness of the surface. One known technique uses a fine needle or stylus, in contact with the surface, in a device sometimes called a profilometer. The needle or

stylus is traversed over the surface, and deflections of the needle caused by surface irregularities are detected and measured. One known device using this principle is sold under the Trade Marks TALYSTEP or TALYSURF by Rank Taylor Hobson Limited. Such a device is also described in UK Patent Specification GB 1,436,721. This specification is also incorporated herein by reference. Surface topography can also be determined by other methods, e.g. using techniques referred to as scanning tip microscopies, reviewed in a paper (also incorporated herein by reference) entitled "Historical Development of Scanning Tip Microscopies" by E. Clayton Teague, 5th Int. Conf. on Precision Engineering, 18-22 Sept. 1989, Monterey, California, pages 17-24. These techniques involve the precise mechanical scanning of a very fine tip, very close to but not in contact with the surface, while monitoring some physical interaction between the tip and the surface. The height of the tip above the surface is servo controlled to maintain a constant value for the interaction, and the servo output gives height information for the measurement of the surface topography. Such scanning tip microscopies include scanning field emission microscopy, scanning tunnelling microscopy, scanning thermal microscopy, and near-field scanning optical microscopy. Other surface topography measurement methods involve optical probes or probes which sense the capacitance between a sensor and the surface.

SUMMARY OF THE INVENTION

The present invention stems from a realisation by the inventor that these two disparate types of technique, spectrographic analysis and surface topography measurement, can yield even more useful results if combined. The invention therefore provides methods and apparatus in which the two techniques are used together.

BRIEF DESCRIPTION OF THE DRAWINGS

Apparatus embodying the invention will now be described by way of example, with reference to the accompanying drawings, wherein:

Fig 1 is a schematic representation of a first apparatus,

Fig 2 is an enlarged vertical cross-sectional detail of part of the apparatus of Fig 1,

Fig 3 is a horizontal cross-section of a modification of Fig 2,

Fig 4 is an enlarged elevation of a sample which can be analysed using the apparatus,

Figs 5 and 6 are schematic representations of parts of two further apparatuses,

Fig 7 is a plan view of a detector for use in the apparatuses of Figs 5 and 6,

Figs 8 and 9 are schematic representations of another two apparatuses,

Fig 10 is a sectional view of a probe tip above a sample surface, and

Fig 11 is a schematic representation of yet another apparatus.

DESCRIPTION OF PREFERRED EMBODIMENTS

Referring firstly to Fig 1, the apparatus includes a table or stage 10, upon which a sample 12 to be analysed can be mounted. The table 10 is provided with precision drives and precision measurement transducers, in a well known manner, so that it can be moved in the two horizontal directions X and Y. The free end 16 of a fine needle 14 rests on the surface of the sample 12, and traverses the sample surface as the table 10 is moved. The tip 16 of the needle 14 is extremely fine, so that the needle 14 is caused to move in response to microscopic variations in the profile of the surface of the sample 12. These movements of the needle 14 are picked up by a profile measurement

device 18. This device 18 and the X,Y movement of the table 10, are controlled by a computer 20, as the tip 16 scans an area of the surface of the sample 12, so as to build up a picture of the height profile of the surface at every point within the area. The arrangement so far described uses well known techniques such as found in the surface profile measurement devices sold under the Trade Marks TALYSTEP or TALYSURF, mentioned above.

This surface profile measurement is combined with Raman analysis apparatus generally of the type described in WO90/07108, to which reference should be made for further details. Briefly, light from a laser 22 is directed onto the surface of the sample 12, in a manner described more fully below. Raman scattering occurs, depending upon the molecular species present in the sample surface, and the resulting Raman spectrum is taken to a Raman analyser 24, again in a manner described below. The analyser 24, which is desirably also controlled by the computer 20, contains filters and other optical components as described in WO90/07108. The analyser 24 may be used in any of the ways described in that specification, including tuning a tunable filter thereof so as to select a line of the Raman spectrum which is characteristic of a molecular species of interest in the sample 12. Alternatively, the tunable filter of that specification may be replaced by a fixed filter, which selects just one desired Raman line. This makes a simpler, cheaper apparatus which is dedicated to the analysis of a specific molecular species, e.g. for use in a specific application. The Raman analyser 24 may be used in either the microscope or microprobe modes as described in that specification. Either way, the output beam of the analyser is taken to a suitable detector, such as a charge coupled device (CCD) 26 which produces a two-dimensional video image of the sample. This image can be analysed pixel by pixel in the computer 20. If used in the microprobe mode, the tunable filter may be replaced by a diffraction

grating, allowing several lines of the Raman spectrum to be dispersed across the CCD 26.

If it is desired to use the Raman analyser in microscope mode, illuminating a relatively large area of the surface of the sample 12 and forming a two-dimensional image thereof on the CCD 26, then the illuminating light from the laser 22 is fed via the Raman analyser 24, as indicated by broken line 28, and through a microscope objective lens system 32 to the sample. This is the same arrangement as shown in WO90/07108. The two-dimensional image of the surface of the sample 12 is focused onto the CCD 26 through the microscope objective 32. The needle tip 16 of the surface profile measurement device will be visible in this two-dimensional image. This enables the computer 20 to correlate the position of the surface profile measurement derived by the device 18 at any given instant with the position in the two-dimensional image produced by the Raman apparatus. Alternatively, since the X,Y positions of the microscope objective 32 and the needle tip 16 are fixed relative to each other, the position of the tip 16 relative to the CCD 26 may be determined only once and then stored in the computer 20 for use in the future correlation of the positions of profile measurements relative to the CCD image. In this way, the computer 20 builds up a two-dimensional picture which gives information about microscopic surface profile (height) variations, correlated with information about the variations in composition of the sample surface from place to place. In many samples, of course, the two will be closely related.

It is also possible, if desired, to construct the Raman analyser 24 in such a way that the Raman filter is removable. This enables a conventional image to be formed on the CCD 26 using the normal Rayleigh scattered laser light (or even ambient visible light) scattered from the sample surface. This further facilitates correlation of

the position of the surface profile measurement at any given point.

Particularly when the Raman analyser is to be used in microprobe mode, instead of microscope mode, the incident light from the laser 22 may be fed to the sample 12 as indicated by the broken line 30, instead of the broken line 28. In this case, the needle 14 comprises an optical fibre, having a light transmitting core 34 as seen in Fig 2. Thus, the incident light from the laser is fed along the needle 14 itself to the surface of the sample 12. The tip 16 of the needle 14 is made from glass, and is so designed as to bring the incident light travelling along the core 34 to a focus on the surface of the sample 12, at or very near to the point of contact between the tip 16 and the sample surface. The microscope objective 32 is focused onto the spot of light thus produced on the sample surface, to receive the scattered light from it, and pass it to the Raman analyser 24 as described above.

As an alternative to the use of the microscope objective 32, the needle 14 may comprise not just a single optical fibre core 34, but multiple cores as illustrated in cross-section Fig 3. Here, a single central core 34 feeds the incident laser light to the sample, as in Fig 2. The remaining cores 36 pick up a two-dimensional image of the spot formed on the surface of the sample, which is then taken directly to the Raman analyser 24. This enables microscopic Raman examination of the surface of the sample 12. Alternatively, there may be just one core 34 for incident light, and one core 36 for return light (or several cores 36 used in parallel) so that the Raman analyser can be used in microprobe mode only.

The apparatus described so far has many uses. One particular use illustrated in Fig 4 is for quality assurance of diamond coatings, e.g. on cutting tools or abrasive materials, in which industrial diamonds 38 are

embedded in a substrate 40, e.g. of nickel. To assess the quality of the surface, it is desirable to be able to measure surface profile, for example so as to determine grit size of the diamonds 38, and their distribution. An X-Y scan, with the sample placed on the X-Y table 10, determines such surface profile, using the profile measurement device 14,18. However, by itself this does not determine whether any particular height irregularity is a diamond particle or some other surface irregularity. Therefore, the Raman analyser 24 is used with a Raman filter tuned to the distinctive Raman line at 1332 cm^{-1}, characteristic of diamond. A two-dimensional image is therefore formed on the CCD 26, showing those areas of the sample surface which comprise diamond and those which do not. This can be correlated by the computer 24 with the profile measurements, for example to produce a two-dimensional image showing the profile only of diamond areas of the sample and ignoring irregularities in the substrate. The computer can also calculate the grit size of the diamond areas and the ratio of their distribution to non-diamond substrate areas. Such quality assurance can for example be undertaken after polishing of the surface of the sample, to determine how much diamond has been exposed by the polishing and whether a flat surface has been achieved. Flatness of the surface, for example, can be of importance if the sample is intended as a heat sink, in which a flat area largely consisting of diamond is required for heat-conducting purposes. The same is true if the sample is intended as a bearing surface.

The above description has used a mechanical profile measurement device 14,18. However, if desired, the surface profile may be determined optically, without the need for a mechanical needle 14.

In one optical technique, the microscope objective 32 is used to focus a small spot, e.g. of sub-micron size, on the surface of the sample, and Raman microprobe analysis is

performed as above using this spot, in order to analyse any desired molecular species present at the point of the spot on the sample surface. The relative height of that particular point compared to other points on the sample surface is determined by triangulation techniques, in well known manner, using an off-axis detector. An example of such triangulation techniques is given in US Patent 4,851,843, incorporated herein by reference. An area of the sample 12 is analysed by X-Y scanning using the table 10. For each point on the surface of the sample during such a scan, the computer 20 receives both a height measurement from the triangulation device, and desired information from the Raman analyser and CCD. This is built up into a two-dimensional image, or otherwise analysed as desired in the computer 20.

Another optical method to determine the relative height of a given point on the sample surface is to use confocal Raman spectroscopy techniques within the Raman analyser 24 itself. Confocal Raman spectroscopy is a technique which is used to discriminate in favour of light which has been scattered at the focus of the optical system as opposed to that which has been scattered outside that volume. The general scheme is shown in Figure 5. Light scattered from the focus 42 of lens L1 (which forms the objective lens 32 of Fig 1) is again brought to a focus by lens L2. At this point a spatial filter, a screen with a pinhole P, is introduced into the optical system. Light from the focus 42 of lens L1 passes through the pinhole, while light which is scattered from other points is blocked by the screen (for example as indicated by broken line 43). Lens L3 returns the beam to its original parallel path. Referring to WO90/07108, the combination of L2, P and L3 in Figure 5 could be placed conveniently between the dichroic filter which rejects Rayleigh scattered laser light and the tunable rotating filter which selects the desired Raman line.

In fact the Raman apparatus can be used in a confocal manner when used in the microprobe mode, even without the pinhole P and lens L3. Figure 6 illustrates that light from the focus of the collection lens L1 is brought to a tight focus on the CCD while that from outside the focal spot is brought to a more diffuse focus. The effect is illustrated in Figure 7 which is a plan view of the detector 26. A circle a represents the distribution of light scattered from the focus while b represents the more diffuse focus of light 43 scattered from elsewhere. In the microprobe mode a few pixels are binned together by the computer 20 to act as the photodetector. If these are chosen, for example, as the four dotted pixels 44 in Figure 7, then the CCD is acting in the same way as the pinhole screen P in Figure 5. Thus confocal behaviour has been attained without the use of an extra spatial filter.

For further details of such confocal techniques which can be used, reference should be made to our concurrently filed International Patent Application No. ....., applicant's reference 231WO, which claims priority from U.K. Patent Application Nos. 9112343.0 and 9120022.0.

Whichever of these confocal techniques is used, the height of the illuminated spot on the sample surface is determined as follows. The microscope objective 32 (lens L1) is focused to a spot in the normal way, by movement as indicated by the arrows 46 in Figs 5 and 6. For example, this can be done under the control of the computer 20, on a continuous basis as the spot is scanned in the X and Y directions across the sample surface, the computer continually servoing the focus so as to achieve maximum illumination of the pixels 44. The movement required to achieve this in the direction of the arrows 46 is thus a measure of the height of the illuminated point on the sample surface, enabling the computer 20 to determine the height. Simultaneously, the computer also obtains the desired information about the concentration of the

molecular species indicated by the selected Raman line, at the point concerned, by measuring the intensity of the maximum just obtained on the pixels 44. The height information and the Raman information are used as previously.

Fig 8 shows an embodiment using near-field microscopy. A light source such as a laser 50 directs light along a waveguide 52. A thin sample 54 is placed on the waveguide, in such as a manner as to induce an evanescent mode of propagation of the light, such that scattering of the light occurs within the sample. A fine-tipped optical probe 56 comprises an aperture sensitive to the near-field effect of the scattered light at the surface of the sample 54. From the probe 56, the scattered light passing through the aperture is taken (e.g. using an optical fibre) to a photodetector 58, via a dichroic filter 60 which transmits the Rayleigh scattered portion of the light. The output of the photodetector 58 is used to control a servo drive 62, which controls the height of the probe tip 56 above the sample 54 as indicated by arrows 64. The near-field effect reduces exponentially with the distance of the probe tip 56 from the surface of the sample 54, and the servo drive 62 acts to ensure a constant amount of light received through the aperture of the probe by the near-field effect, and thus a constant height of the probe tip above the sample surface. This height will usually be set to be less than 0.1μm, and may be of the order of nanometres, in order to obtain the near-field effect. An output 66 from the servo drive 62 is fed to a computer 20, and represents the local height of the surface of the sample 54, i.e. the amount of servoing required to maintain a constant distance between the surface and the tip of the probe 56. The computer 20 controls an X-Y drive 68, which causes raster scanning of the probe 56 over the surface of the sample 54 (or alternatively, raster scanning of the sample 54 supported on the waveguide 52, relative to the probe 56). The computer 20 contains conventional software which enables a

three-dimensional picture to be built up of the surface topography of the sample 54.

The dichroic filter 60 reflects Raman scattered light received by the probe 56 from the sample 54 and passes it to a Raman analyser 24 and cooled CCD detector 26. These operate in the manner discussed above, in the microprobe mode. Simultaneously with reading the topographical information on the line 66, the computer 20 reads the Raman spectroscopic information from the CCD 26. This enables the computer to incorporate in its three-dimensional picture the information on local composition at each position on the surface of the sample.

The Raman information can also be used to give information about local strain from place to place on the surface of the sample, since strain shifts the Raman spectrum.

Fig 9 shows a modification of the apparatus of Fig 8. Instead of supporting the sample 54 on a wave guide, the exciting light from the laser 50 is fed down the optical probe 56. The optical probe is in the form of an optical fibre having a very fine tip 70, forming an aperture which has a near-field interaction with the surface of the sample 54. Light resulting from the near-field interaction is transmitted through the thin sample 54 and collected by a microscope objective 72. This light passes through a dichroic filter 60, photodetector 58, servo drive 66, Raman analyser 24, all of which operate in a similar manner to the corresponding components in Fig 8. Other parts of the system are also as found in Fig 8, and a three-dimensional picture is built up in which topographical information and information derived from the Raman analysis (e.g. composition or strain) are correlated, as previously. The diameter of the tip 70 is desirably less than 0.1μm. Alternatively, however, this diameter may be set somewhat higher, in the region of 0.2μm. In this case, the near-field effect is reduced, and conventional back-scattering

takes place, scattered light passing back up the optical fibre. In this arrangement, the microscope objective 72 is not required, and the dichroic filter 60, photodetector 58, Raman analyser 24, etc are located on the return path along the optical fibre, as in Fig 8.

Fig 10 shows a probe which may be used in apparatus similar to Figs 1 to 3, but using a scanning tip microscopy such as atomic force microscopy or scanning tunnelling microscopy, in place of the stylus 16 in contact with the surface of the sample. The probe comprises a central core 76 having a very fine probe tip 78, of the type normally used for such forms of microscopy. This fine tip 78 is maintained at a very small distance above the surface of the sample 80, by monitoring the atomic force or tunnelling of electrons or other interaction between the tip and the sample, and using a servo drive similar to those of Figs 8 and 9, in the manner well known in such forms of microscopy. As previously, raster scanning takes place between the tip 78 and the sample 80, and height information from the servo drive is fed to a computer to enable a topographical image to be built up, and correlated with the Raman spectroscopic information from place to place on the sample surface.

Surrounding the core 76 is a multiple core optical fibre 82. Laser light is passed down this fibre to form a spot on the surface of the sample 80, and scattered light passes back up the fibre 82 to a Raman analysis device, in any of the arrangements described above in relation to Figs 1 to 3. The information derived from the Raman analysis (e.g. surface composition or strain) is also fed into the computer, which correlates it with the topographical information and incorporates it in the three-dimensional topographical image.

Fig 11 shows another system, which allows the use of separate probes for the Raman analysis and the topographical analysis. A sample 12 is mounted on an X-Y

translatable stage 10, under a probe unit 92. The stage 10 is driven by an X-Y drive 68 for raster scanning relative to the probe unit 92. Alternatively, the probe unit 92 may be scanned over a stationary sample 12. The probe unit 92 contains two separate probes, a fixed, known distance apart from each other. One is a surface topography probe 88, connected to a surface topography detector 84. These may be of any suitable type, including any of the techniques discussed above, such as contacting-type profilometers, near-field optical microscopy, atomic force microscopy, scanning tunnelling microscopy, or any other scanning tip microscopy. The topographical information is fed to a computer 20, as previously, which builds up a three-dimensional topographical image. The other probe 90 in the probe unit 92 acts as a Raman microprobe, of the type discussed above. It is connected to Raman analysis apparatus 86, which directs laser light through the probe 90 to a spot on the sample 12, and receives back the Raman scattered light for analysis. Again, as previously, the results of the Raman analysis are fed to the computer 20 for correlation with the topographical information and incorporation in the final image. Both the topography detector 84 and the Raman analysis apparatus 86 may run simultaneously as the relative scanning between the sample 12 and the probe unit 92 takes place. The correlation which must be performed by the computer 20 is slightly more complex than in the embodiments of Figs 8 and 9, since the two detectors do not simultaneously examine the same point on the sample surface. Nevertheless, with the knowledge of the separation between the probes 88 and 90, the correlation is still straightforward.

Other scanning tip microscopies which may be used with the present invention to derive the topographical information include scanning field emission microscopy, scanning capacitance microscopy, scanning thermal microscopy, scanning ion conductance microscopy, scanning potentiometry microscopy and magnetic force microscopy. The use of these

various microscopies may be achieved by incorporating an appropriate probe tip and detector system in the various embodiments described above. Scanning tip microscopies which may be used are described in the following papers, which are incorporated herein by reference:

New Fields for STMs, J Gimzewski, Physics World, August 1989, pages 25-28;

Optical Microscope Targets Molecular Resolution, U Fischer, Physics World, April 1992, pages 26-27;

Observation of Machined Surfaces Using the Scanning Tunneling Microscope, D A Grigg et al, 5th Int. Conf. on Precision Engineering, 18-22 September 1989, Monterey, California, pages 25-45;

A Lewis et al, Ultra Microscopy, 13, 1984, 227;

E Betzig et al, Appl. Opt. 25, 1986, 1890;

D Pohl, Proc. SPIE, 897, (1988), 84;

D Pohl, 1990, Advances in Optical and Electrical Microscopy;

Pohl et al, J. Appl. Phys, 59, 1986, 3318.

One advantage of certain embodiments of the present invention is as follows. The Raman information can give information about strain in the sample, as discussed above. Furthermore, surface topology measurements by scanning tunnelling microscopy, atomic force microscopy and similar techniques can have ultra-high resolution, down as far as 0.1nm, and can detect the spacings between individual molecules or atoms of a crystalline structure of the sample. Thus, the correlated image produced by the computer can show how the molecular or atomic spacings are related to strain in the sample, even though the resolution of the Raman information may be somewhat less than that of the topographical information (e.g. it may be of the order of 1μm).

The invention also includes other techniques for determining surface profile, e.g. using capacitance probes,

in combination with Raman analysis. Furthermore, other spectroscopic techniques can be used, such as fluorescence spectroscopy or infra-red spectroscopy, in place of Raman spectroscopy.

Another use for the apparatus described is in the semiconductor manufacturing industry, to measure line widths of silicon and polymer photolithographic materials during masking and deposition processes. It is important to be able to determine the edges and sharpnesses of the polymer and silicon boundaries. The Raman analyser 24 can be tuned to pick up critical Raman lines for silicon and for the various polymers used. Images can be obtained over an area, and defects at edges with critical breakdowns can be detected. Also, when combined with the profile determination techniques discussed above, the heights of polymer depositions can be correlated with the image. This combination of Raman with edge profiling is useful to define the exact position of an edge to enable line widths to be determined. It can also be used to measure the width and depth of (say) a channel etched in a semiconductor substrate, such as gallium aluminium arsenide, and indicate the relative proportions of the gallium and the aluminium at the bottom of the channel, compared with those at the substrate surface.

CLAIMS

1. Apparatus for analysing the surface of a sample, comprising:

topography measuring means for providing information on the topography of the surface, from place to place on the surface;

spectrographic analysing means for providing spectrographic information characteristic of the surface, from place to place on the surface; and

means for correlating the topography information for a given place on the surface with the spectrographic information for that given place.

2. Apparatus according to claim 1, wherein the spectrographic analysing means comprises means for analysing Raman scattered light from the sample.

3. Apparatus according to claim 1 or claim 2, wherein the topography measuring means comprises means for scanning a stylus in contact with the surface of the sample, and means for measuring deflection of said stylus.

4. Apparatus according to claim 1 or claim 2, wherein the topography measuring means comprises a scanning probe tip, and means for maintaining said tip spaced from the surface of the sample.

5. Apparatus according to claim 4, wherein the topography measuring means comprises an atomic force microscope or scanning tunnelling microscope.

6. Apparatus according to claim 1, claim 2, or claim 4 wherein the topography measuring means comprises optical means for measuring the height of points on the sample surface.

7. Apparatus according to claim 6, wherein the optical means comprises a near-field scanning optical microscope.

8. Apparatus according to claim 6, wherein said optical means comprises means for focusing a light spot on the surface, and a confocal optical system for imaging said spot and rejecting light which is not in focus.

9. Apparatus according to claim 8, wherein the confocal optical system comprises a confocal photodetector onto which the spot is imaged, light which is not in focus being rejected by the photodetector.

Fig. 1.

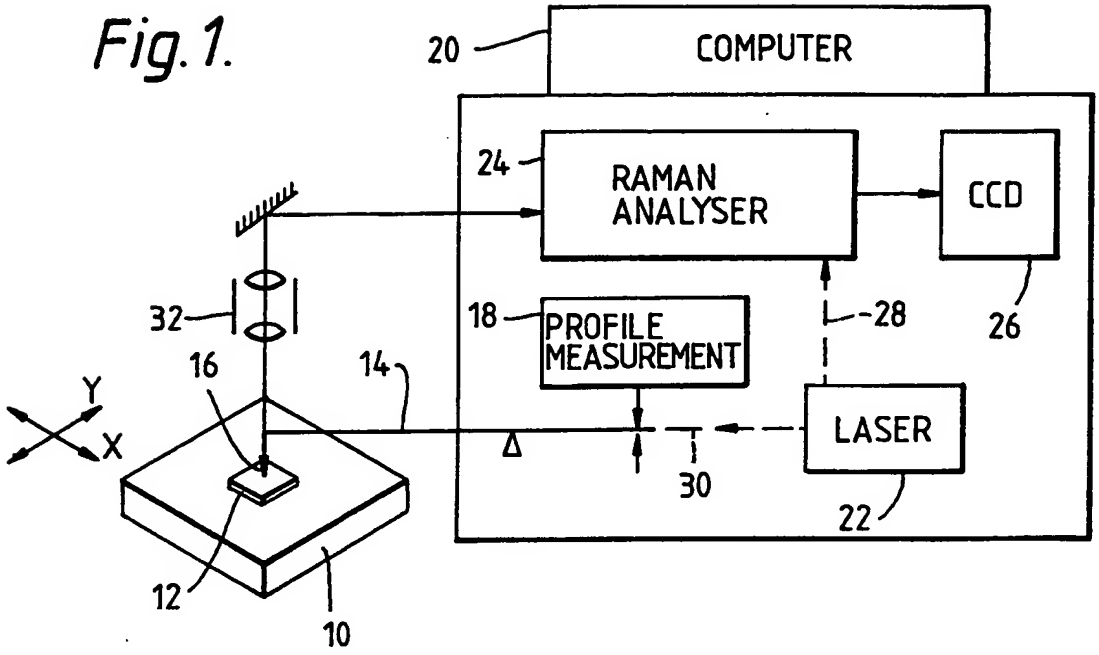


Fig. 2.

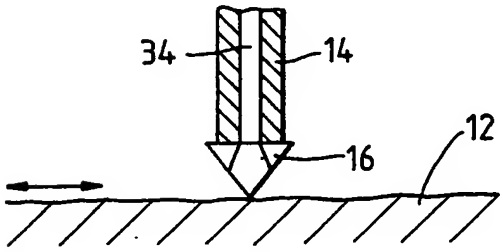


Fig. 3.

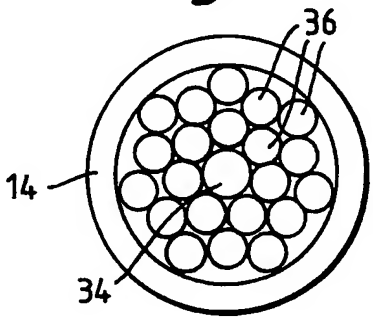


Fig. 4.

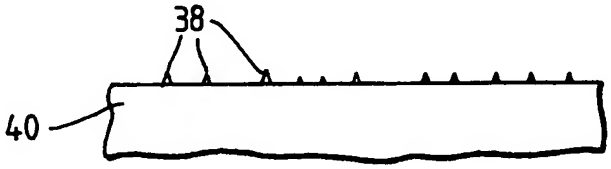


Fig.5.

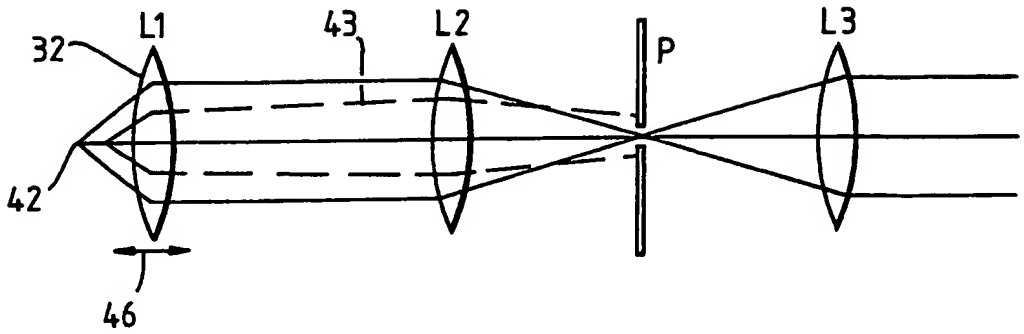


Fig.6.

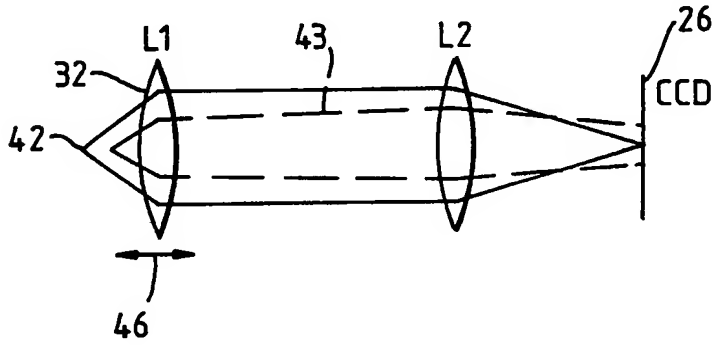


Fig.7.

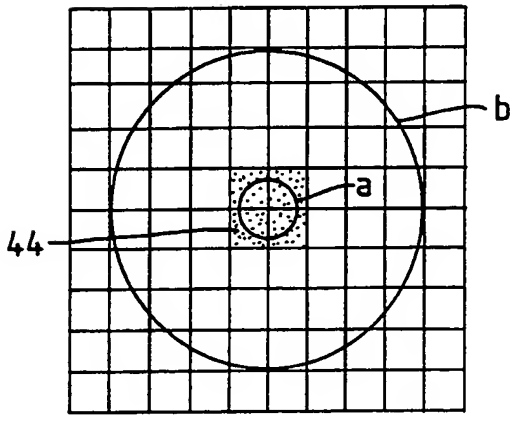
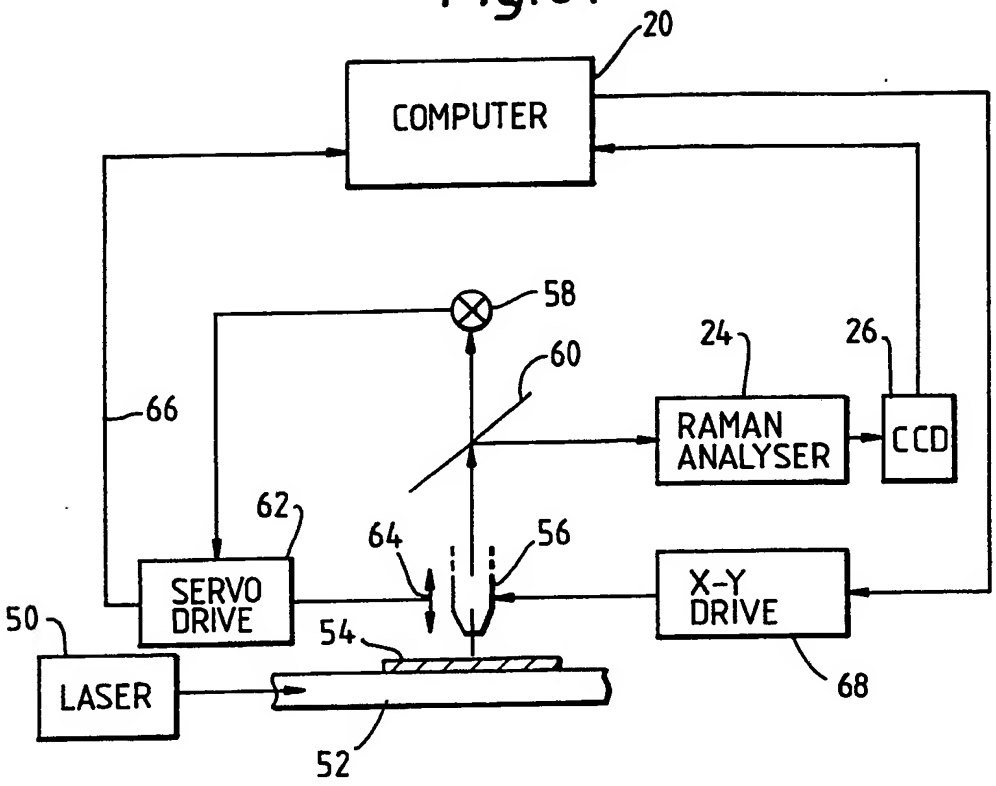


Fig.8.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COMPUTER
58
60
24
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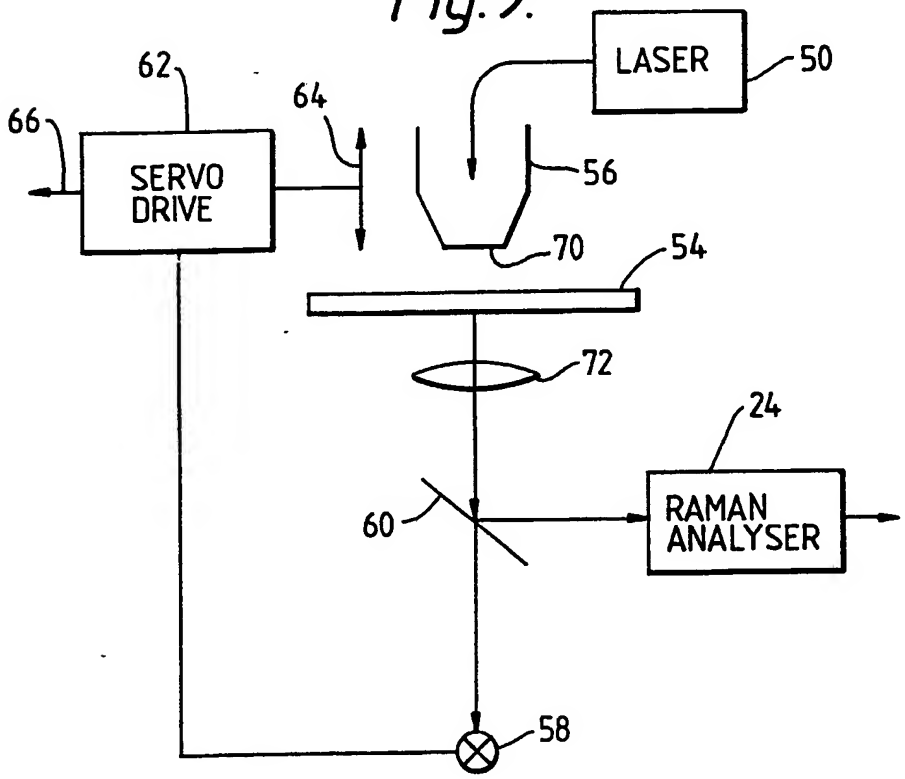
RAMAN ANALYSER
CCD
62
64
56
SERVO DRIVE
X-Y DRIVE
50
54
LASER
68
52

Fig.9.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64
SERVO DRIVE
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70
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72
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60
RAMAN ANALYSER
58

Fig.10.

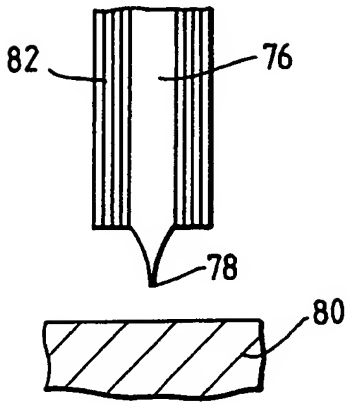
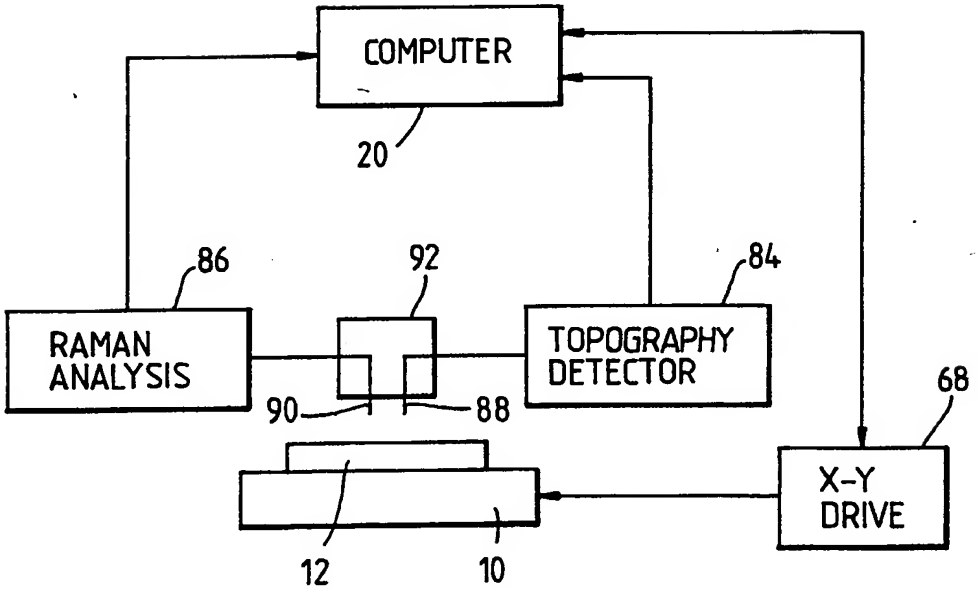

82
76
78
80

Fig.11.


COMPUTER
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86
92
84
RAMAN ANALYSIS
TOPOGRAPHY DETECTOR
90
88
68
X-Y DRIVE
12
10

INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 92/01025

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 5 G01N21/65; G01B11/30; G02B21/00; G01N27/00

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl. 5	G01J ; G01N ; G02B ; G01B

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category °	Citation of Document,[11] with indication, where appropriate, of the relevant passages[12]	Relevant to Claim No.[13]
X	US,A,4 942 299 (L.L. KAZMERSKI) 17 July 1990 see column 6, line 14 - line 64; claims 16-23	1
X	EP,A,0 426 571 (SPIRAL - RECHERCHE ET DEVELOPPEMENT) 8 May 1991 see page 28, line 24 - line 32 see page 16, line 46 - line 56 see page 13, line 20 - line 38 see claims 1,2,13; figure 1	1,2,6,7
X	REVIEW OF SCIENTIFIC INSTRUMENTS. vol. 61, no. 12, December 1990, NEW YORK US pages 3669 - 3677; R.C.REDDICK ET AL.: 'photon scanning tunneling microscopy' see page 3677	1,2,5-7

-/--

° Special categories of cited documents :[10]

"A" document defining the general state of the art which is not considered to be of particular relevance

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
09 SEPTEMBER 1992	22.09.92
International Searching Authority	**Signature of Authorized Officer**
EUR PEAN PATENT FFICE	VAN DEN BULCKE E.J.

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category [a]	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
X	FR,A,2 596 863 (C.N.R.S.) 9 October 1987 see page 16, line 34 - page 17, line 5; claims 1,2	1,2
A	JOURNAL OF VACUUM SCIENCE AND TECHNOLOGY: PART A. vol. 8, no. 1, February 1990, NEW YORK US pages 363 - 368; H.KUMAR .: 'scanning probe microscopy: current status and future trends' see page 363 - page 368	4,5
A	EP,A,0 056 426 (FIRMA CARL ZEISS) 28 July 1982	

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. GB 9201025 SA 60144

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 09/09/92
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
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		CN-A-	1052373	19-06-91
		WO-A-	9106884	16-05-91
FR-A-2596863	09-10-87	None		
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